MgII h&k spectra of an enhanced network region simulated with the MURaM code

Patrick Ondratschek, Damien Przybylski, Sami Solanki,
Smitha Narayanamurthy, Robert Cameron
Hinode-15/IRIS-12

MAX PLANCK INSTITUTE
FOR SOLAR SYSTEM RESEARCH

IMPRS
for Solar System Science at the University of Göttingen
INTERNATIONAL MAX PLANCK RESEARCH SCHOOL
SOLAR SYSTEM SCHOOL

ondratschek@mps.mpg.de

Motivation

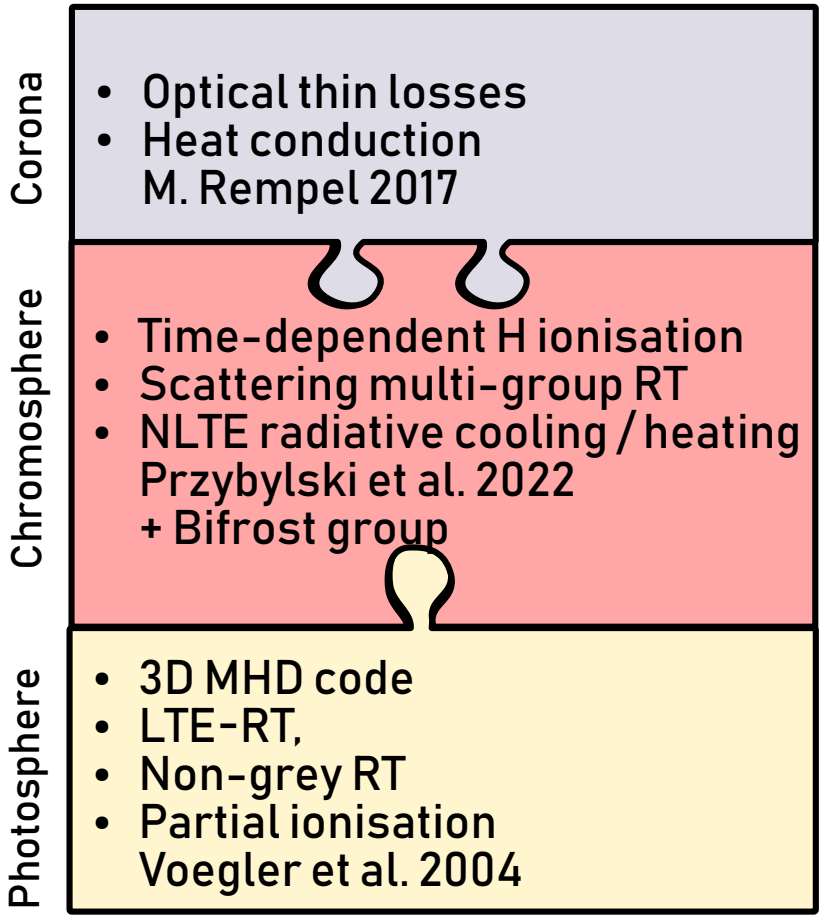
- Modeling the chromosphere is especially complicated due to NE and NLTE effects.
- Simulations can reproduce shapes and structures observed in different wavelengths .
- However, detailed comparisons show discrepancies.

  For example: peak intensities or line widths of important chromospheric lines such as MgII k.

Outline

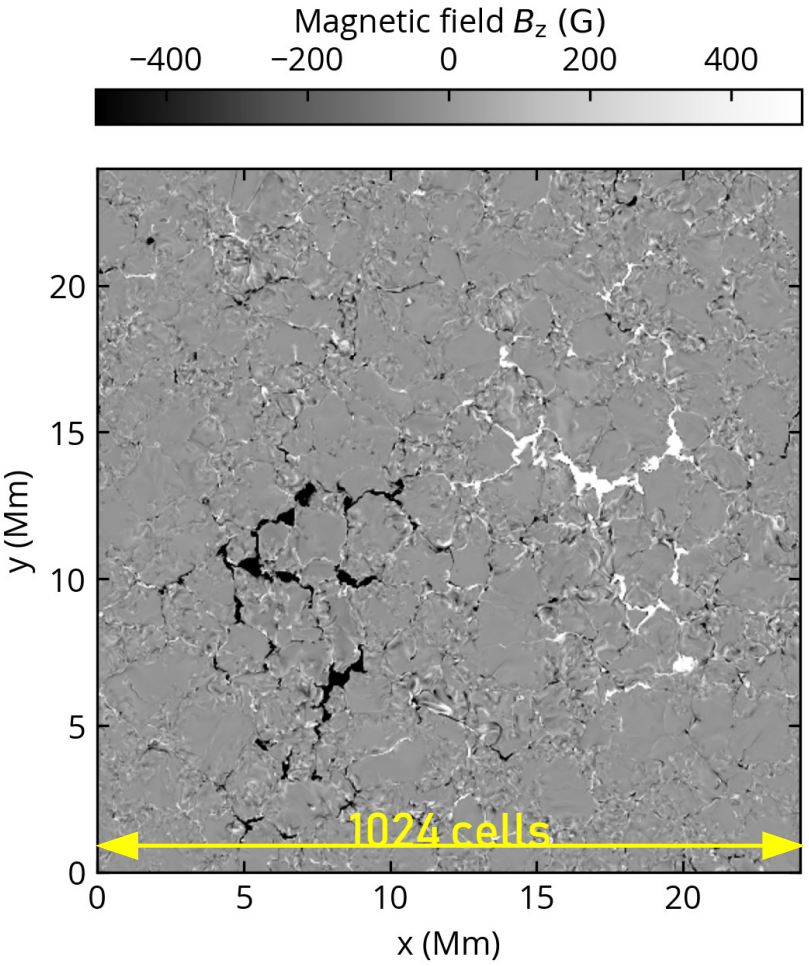
- What is the MURaM enhanced network model?
- How do we synthesize spectra?
- How do our results compare to other models and observations?
- Conclusions and outlook

The MURaM code



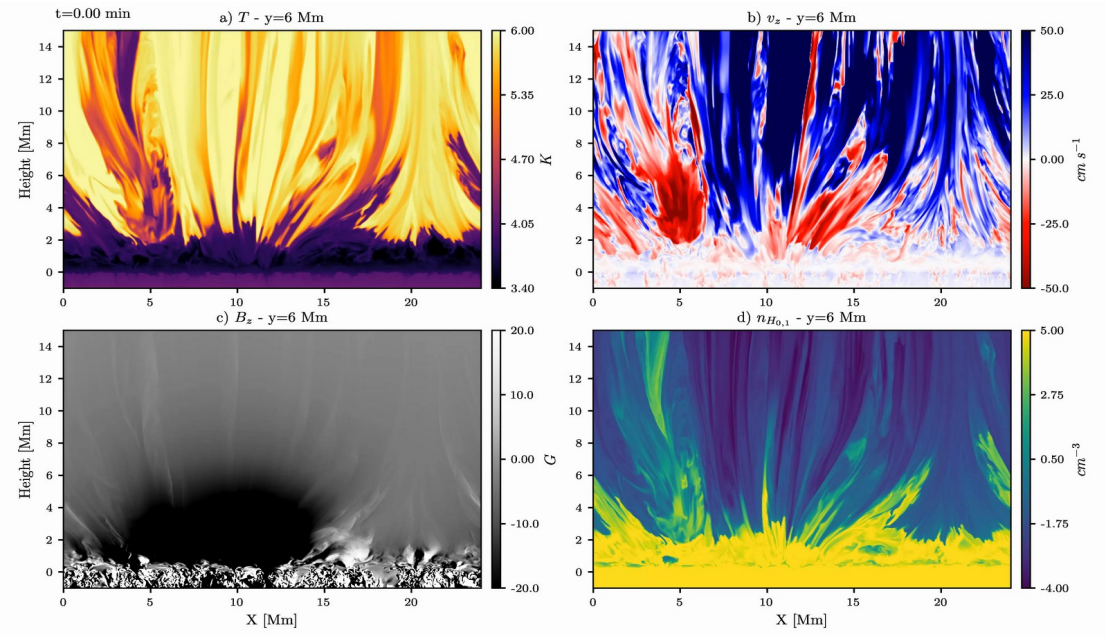
- MURaM can simulate atmospheres from the Photosphere up to the Corona at the same time.
- MURaM has been optimezed to run at low diffusivity, using the slope-limited scheme of Rempel (2009, 2014).
- The computed electron number and temperature profiles in NLTE allow accurate radiative transfer computations of important chromospheric spectral lines.

The enhanced network model



Temperature

Vertical velocity

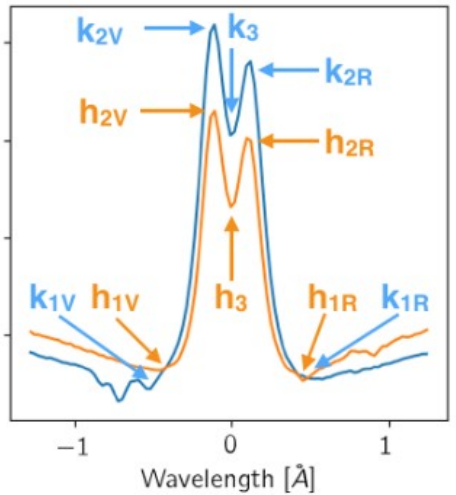


Vertical magnetic field

Density

Radiation transfer

- We use RH1.5D (Pereira & Uitenbroek, 2015; Uitenbroek, 2001) to synthesize spectra from the MURaM model.
- The 1.5D approach treats each column individually as a plane-parallel atmoshpere.
- The MgII h&k lines are computed in PRD and NLTE.



Nomenclature:

k1: wings
k2: peaks
k3: central depression
v = blue
r = red

See: ITN 39

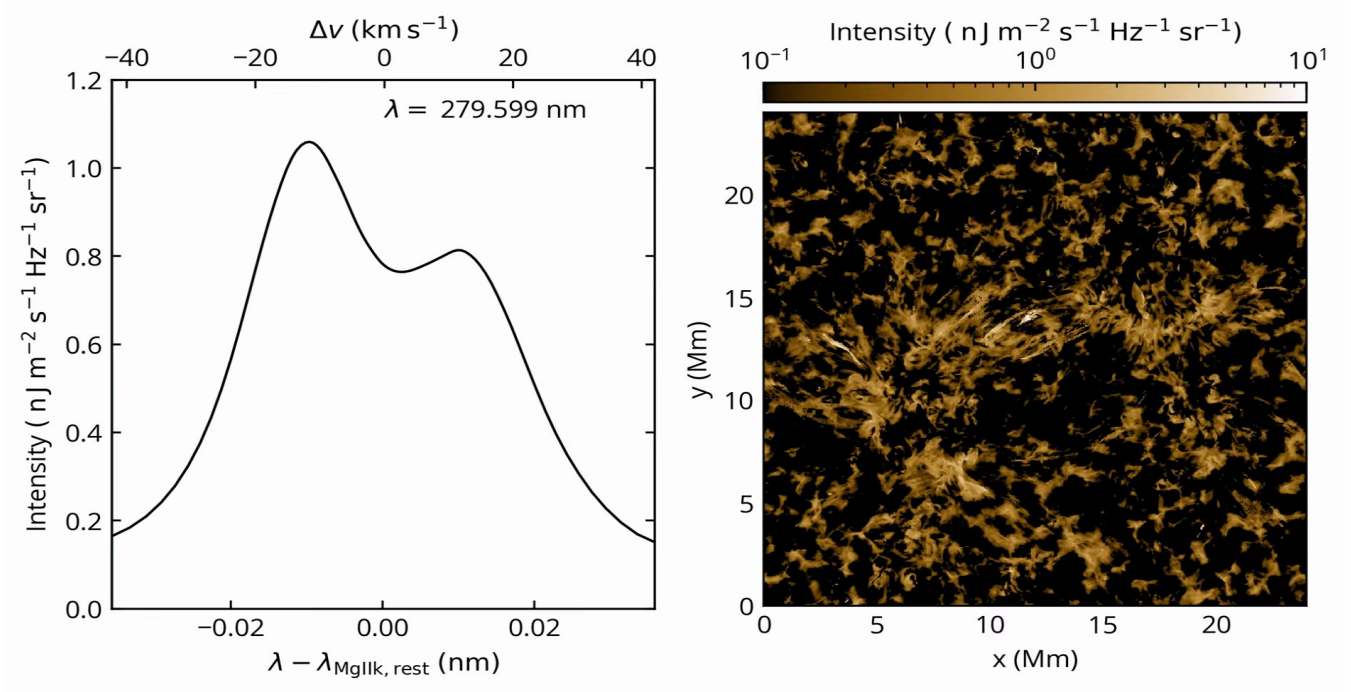
Model atmosphere
Density, B,v

In NLTE:
+ electron number (H)
+ population levels (H)
+ Temperature

RH1.5D

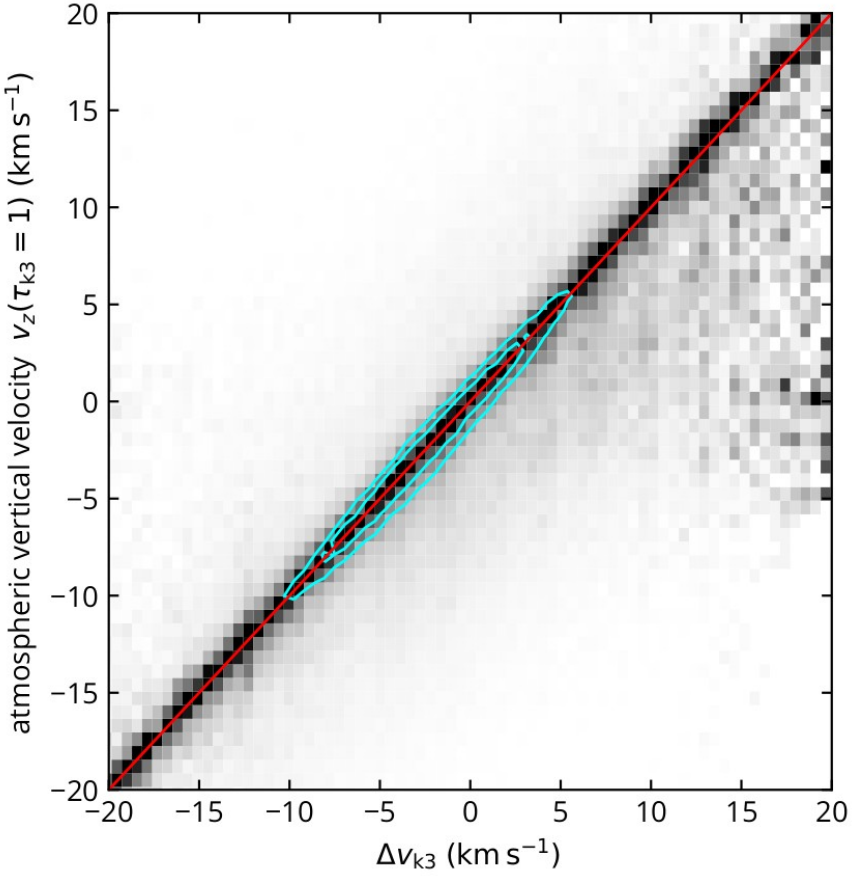
Synthetic spectra

Results: Synthetic Spectra



In the line core, the intensity resembles magnetic field structures in the upper chromosphere.

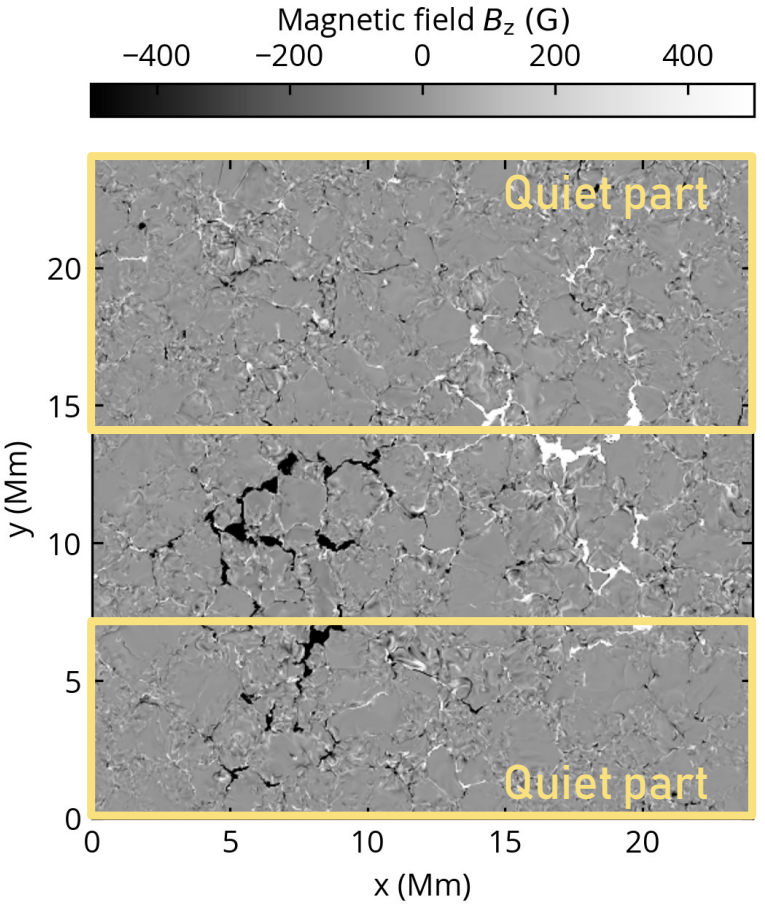
Relation between spectral features and atmosphere



- Agreement with observations from forward modeled spectra with Bifrost and Multi3D (Leenaarts 2013 et al.)
- Strong correlation between Doppler shift of line core and vertical velocity in the atmosphere

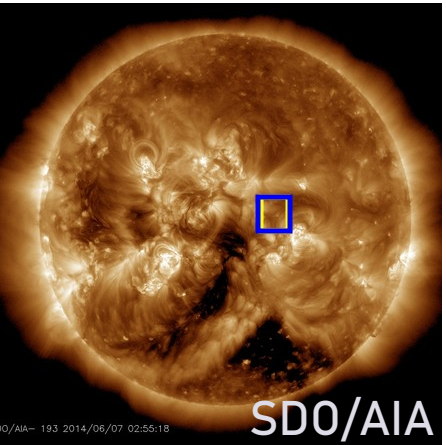
Comparison to observations

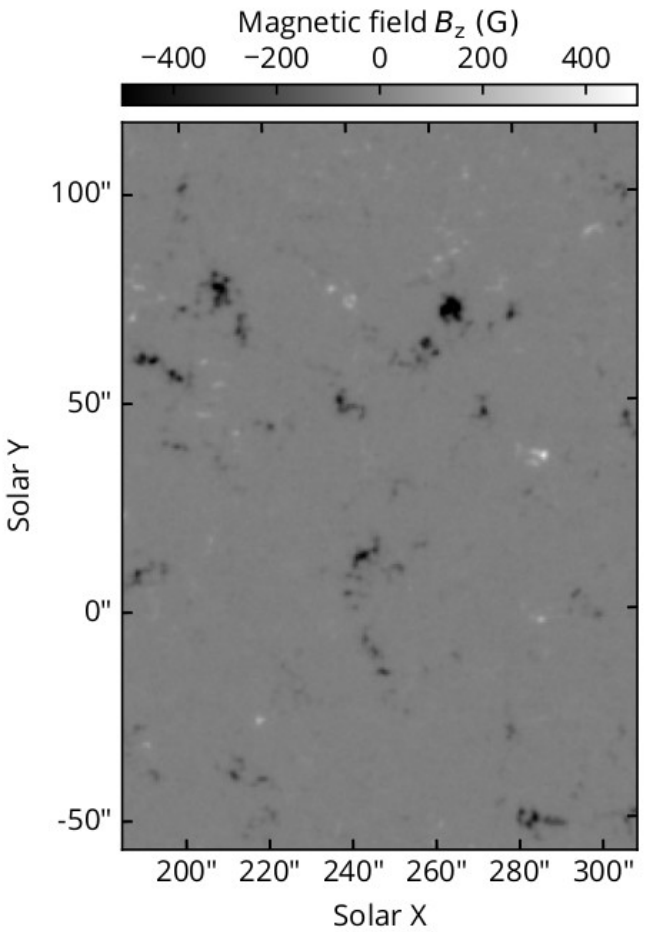
- We degrade the spectra to IRIS resolution for reasonable comparisons
- We select regions of low magnetic activity to resemble quiet sun regions
- For comparisons with the Bifrost model we use data from the publicly available enhanced network snapshot (Carlsson 2016 et al.)

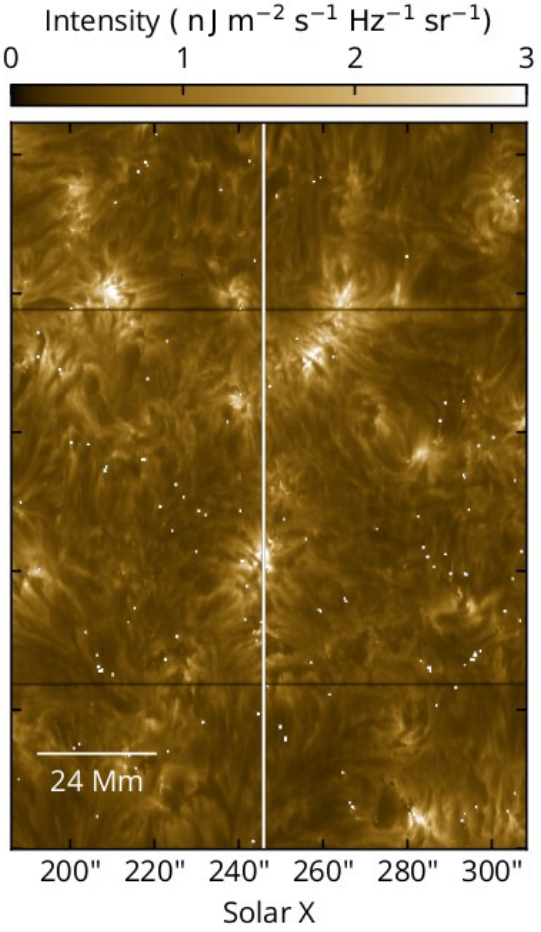


Observation sample

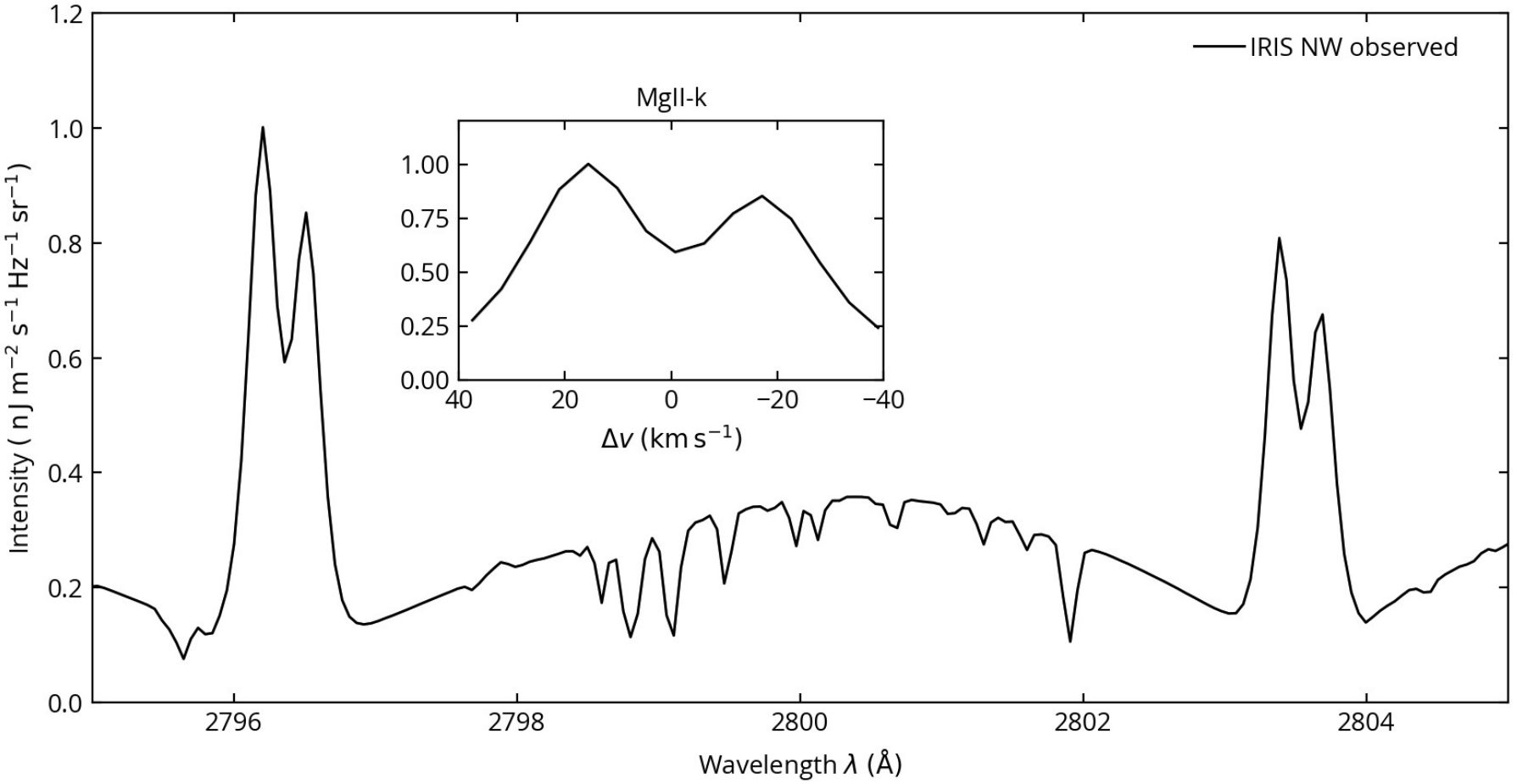
- Left: HMI magnetogram
- Right: IRIS observations
- The field of view shows quiet sun and network regions



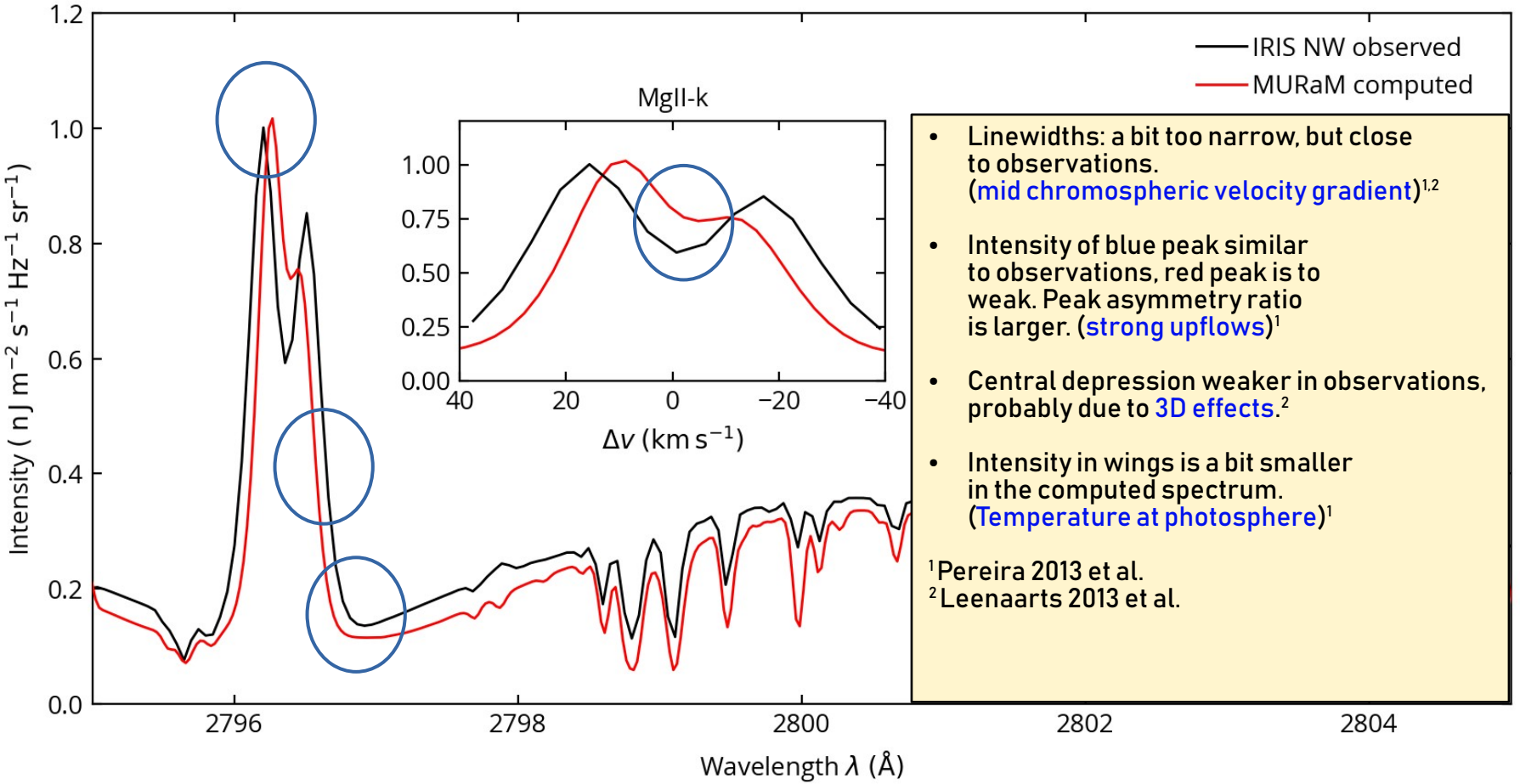




Average spectra



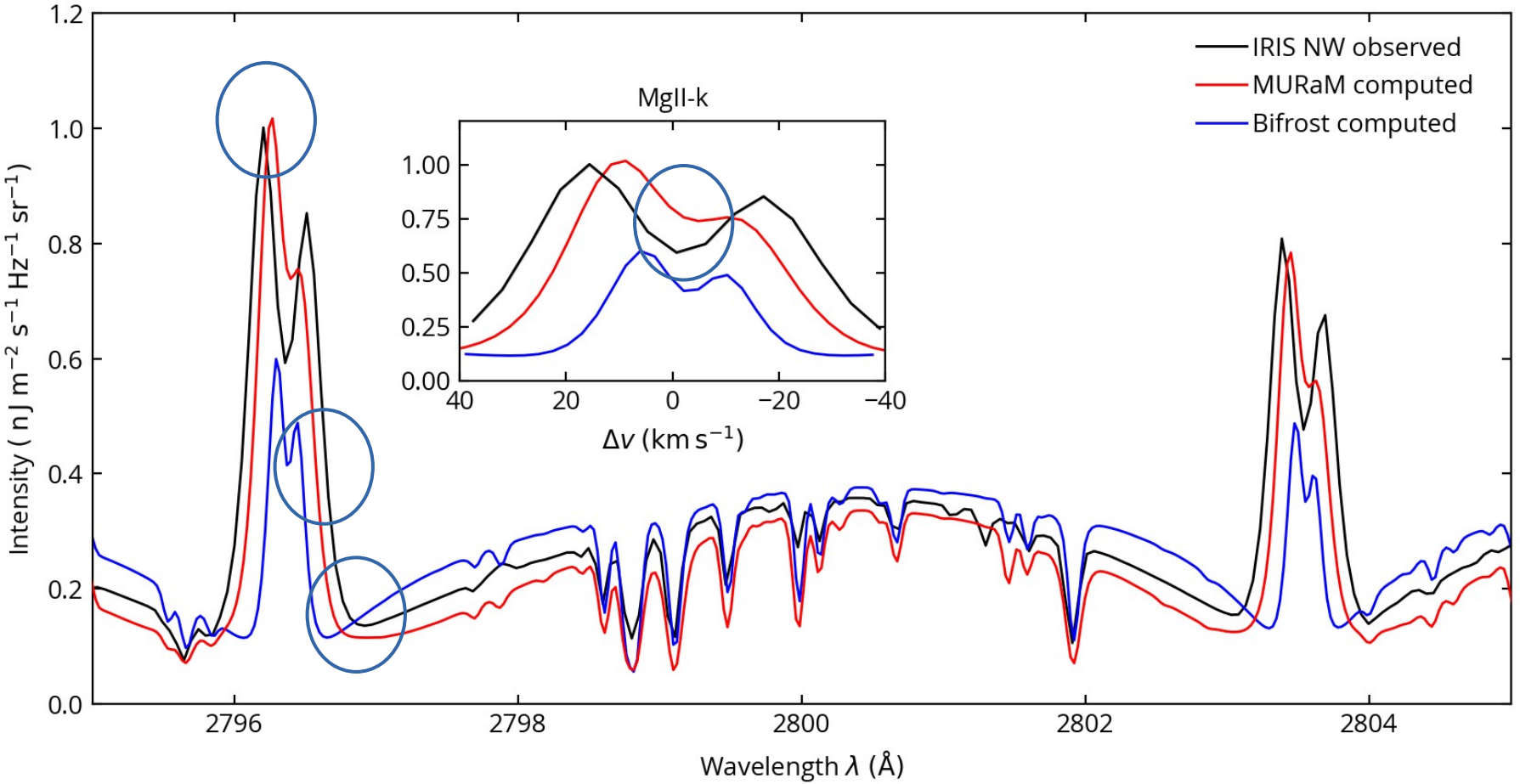
Average spectra



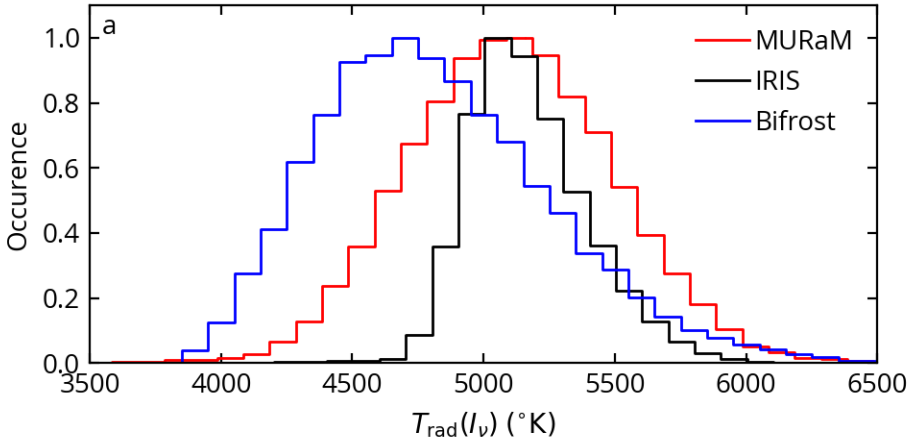
- Linewidths: a bit too narrow, but close to observations. (mid chromospheric velocity gradient)[1,2]
- Intensity of blue peak similar to observations, red peak is to weak. Peak asymmetry ratio is larger. (strong upflows)[1]
- Central depression weaker in observations, probably due to 3D effects.[2]
- Intensity in wings is a bit smaller in the computed spectrum. (Temperature at photosphere)[1]

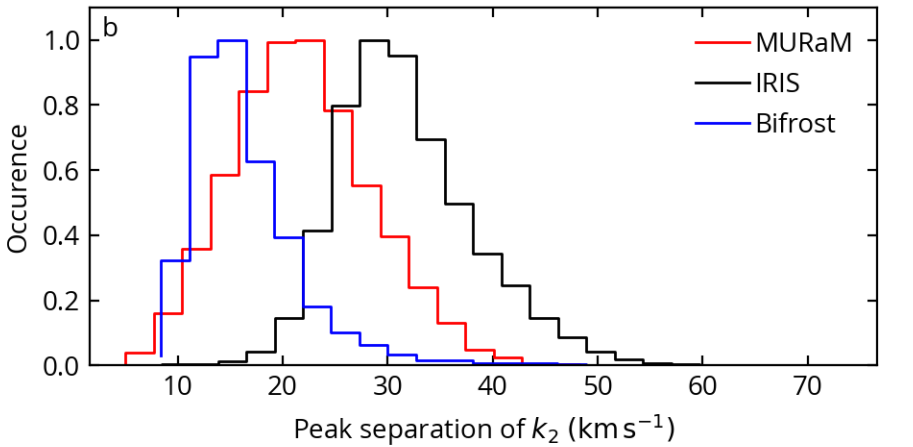
[1] Pereira 2013 et al.
[2] Leenaarts 2013 et al.

Average spectra



Peak separations





- On average, MURaM peak intensities are higher than Bifrost and closer to the IRIS observation.
- The peak separations are larger, but smaller than observed profiles.
- In MURaM the atmosphere is more turbulent which leads to broader profiles and larger peak separations.

Conclusions and outlook

Conclusions:

- With the chromospheric extension of MURaM it is possible to synthesize important spectral lines such as MgII h&k at a new level.
- The forward modeled spectra show similar relations between spectral features and the simulated atmospheres as previous models.
- On average, the spectral lines are broader and show larger peak separations than previous models.

Outlook:

- Study time series and mimic exposure time
- Compare regions of similar magnetic flux (activity)
- Extend simulation box

Thanks!